Experiment

Solution

A2

Korean (Korea (Republic of))

Asian Physics Olympiad

Q2 광학적 방법으로 시료의 공간 구조 탐구하기

풀이

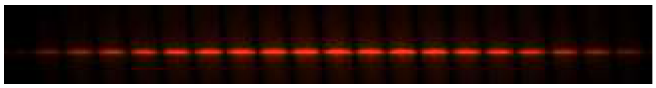
파트 A. 빛과 시료의 정렬

A.1 0.5 pt

$(X_{sample},\ Y_{sample})$ = **(3700, -2900)**

A.2 0.5 pt

간섭 무늬:



차수, 무늬	-2, 어두움	-1, 어두움	1, 어두움	2, 어두움
(*x*, *y*)	**(-0.98 , 0)**	**(-0.38, 0)**	**(0.34, 0)**	**(0.98, 0)**
S (cm)	**0.98**	**0.38**	**0.34**	**0.98**
ΔS (cm)	**0.65**			

파트 B. 시료 구조 크기의 탐구

B.1 0.5 pt

$$d = \frac{m \times \lambda}{\sin\left(\tan^{-1}\left(\frac{S}{L}\right)\right)}$$

Experiment

Solution

A2

Korean (Korea (Republic of))

B.2 1.5 pt

L = **60 cm**

λ = **488 nm**

Data	1	2	3	4	5
(x, y)	**(-4.04, 4.68)**	**(3.00, 5.50)**	**(4.08, -4.60)**	**(5.76, 0.48)**	**(-5.68, 0.56)**
S (cm)	**6.18**	**6.26**	**6.15**	**5.78**	**5.71**
$\bar{S}$ (cm)	6.02 ± 0.11				
$\tan^{-1}\left(\frac{\bar{S}}{L}\right)$	0.0999 ± 0.0019				

λ = **514 nm**

Data	1	2	3	4	5
(x, y)	**(3.32,5.64)**	**(6.16,0.48)**	**(4.46,-4.90)**	**(-3.12,-5.64)**	**(-6,-0.64)**
S (cm)	**6.54**	**6.18**	**6.63**	**6.45**	**6.03**
$\bar{S}$ (cm)	6.37 ± 0.11				
$\tan^{-1}\left(\frac{\bar{S}}{L}\right)$	0.1057 ± 0.0019				

λ = **632.8 nm**

Data	1	2	3	4	5
(x, y)	**(4.04,7.00)**	**(7.44,0.68)**	**(5.24,-5.96)**	**(-3.96,-7.04)**	**(-7.44,-0.**
S (cm)	**8.08**	**7.47**	**7.94**	**8.08**	**7.47**
$\bar{S}$ (cm)	7.81 ± 0.14				
$\tan^{-1}\left(\frac{\bar{S}}{L}\right)$	0.1294 ± 0.0023				

λ = **694.3 nm**

Data	1	2	3	4	5
(x, y)	**(-5.84,6.50)**	**(8.20,0.76)**	**(-4.28,-7.72)**	**(5.96,-6.60)**	**(4.48,7.7**
S (cm)	**8.74**	**8.24**	**8.83**	**8.89**	**8.93**

$\bar{S}$ (cm)	8.73 ± 0.13
$\tan^{-1}\left(\frac{\bar{S}}{L}\right)$	0.1444 ± 0.0021

B.3 1.0 pt

$\bar{a} =$ **5.627 μm**

λ (nm)	d (μm)	a (μm)
488	**4.89**	**5.65**
514	**4.87**	**5.63**
632.8	**4.90**	**5.66**
$\bar{a}$ (μm)		5.627 ± 0.020

파트 C. 시료 구조 크기의 탐구

C.1 0.8 pt

λ = **488 nm**

L=90 cm, 축 1				
차수, 무늬	4, 밝음	5, 밝음	6, 밝음	7, 밝음
(*x*, *y*)	**(3.01, 1.46)**	**(3.67, 1.91)**	**(4.30, 2.24)**	**(5.00, 2.50)**
S (cm)	**3.35**	**4.14**	**4.85**	**5.59**
$\tan^{-1}\left(\frac{S}{L}\right)$	**0.0372**	**0.0459**	**0.0538**	**0.0620**

L=90 cm, 축 2				
차수, 무늬	4, 밝음	5, 밝음	6, 밝음	7, 밝음
(*x*, *y*)	**(-1.64, 3.46)**	**(-2.07, 4.19)**	**(-2.41, 4.95)**	**(-2.87, 5.73)**
S (cm)	**3.83**	**4.67**	**5.51**	**6.41**
$\tan^{-1}\left(\frac{S}{L}\right)$	**0.0425**	**0.0519**	**0.0611**	**0.0711**

λ = **514 nm**

L=90 cm, 축 1				
차수, 무늬	4, 밝음	5, 밝음	6, 밝음	7, 밝음
(*x*, *y*)	**(3.08, 1.56)**	**(3.76, 1.92)**	**(4.44, 2.28)**	**(5.20, 2.60)**
S (cm)	**3.45**	**4.22**	**4.99**	**5.81**
$\tan^{-1}\left(\frac{S}{L}\right)$	**0.0383**	**0.0469**	**0.0554**	**0.0645**

L=90 cm, 축 2				
차수, 무늬	4, 밝음	5, 밝음	6, 밝음	7, 밝음
(x, y)	**(-1.76, 3.68)**	**(-2.26, 4.38)**	**(-2.58, 5.34)**	**(-3.22, 6.04)**
S (cm)	**4.09**	**4.92**	**5.93**	**6.84**
$\tan^{-1}\left(\frac{S}{L}\right)$	**0.0454**	**0.0547**	**0.0658**	**0.0759**

λ = **632.8 nm**

L=90 cm, 축 1				
차수, 무늬	4, 밝음	5, 밝음	6, 밝음	7, 밝음
(x, y)	**(3.84, 1.96)**	**(4.68, 2.44)**	**(5.48, 2.88)**	**(6.44, 3.32)**
S (cm)	**4.31**	**5.28**	**6.19**	**7.25**
$\tan^{-1}\left(\frac{S}{L}\right)$	**0.0479**	**0.0586**	**0.0687**	**0.0803**

L=90 cm, 축 2				
차수, 무늬	4, 밝음	5, 밝음	6, 밝음	7, 밝음
(x, y)	**(-2.28, 4.56)**	**(-2.84, 5.48)**	**(-3.36, 6.52)**	**(-3.84, 7.52)**
S (cm)	**5.10**	**6.17**	**7.33**	**8.44**
$\tan^{-1}\left(\frac{S}{L}\right)$	**0.0566**	**0.0685**	**0.0813**	**0.0935**

λ = **694.3 nm**

L=90 cm, 축 1				
차수, 무늬	4, 밝음	5, 밝음	6, 밝음	7, 밝음
(*x*, *y*)	**(4.24, 2.12)**	**(5.08, 2.80)**	**(6.04, 3.20)**	**(7.04, 3.68)**
S (cm)	**4.74**	**5.80**	**6.84**	**7.96**
$\tan^{-1}\left(\frac{S}{L}\right)$	**0.0526**	**0.0644**	**0.0758**	**0.0882**

L=90 cm, 축 2				
차수, 무늬	4, 밝음	5, 밝음	6, 밝음	7, 밝음
(*x*, *y*)	**(-2.48, 5.00)**	**(-3.08, 6.04)**	**(-3.60, 7.16)**	**(-4.16, 8.28)**
S (cm)	**5.58**	**6.78**	**8.01**	**9.27**
$\tan^{-1}\left(\frac{S}{L}\right)$	**0.0619**	**0.0752**	**0.0888**	**0.103**

Experiment

Solution

A2

Korean (Korea (Republic of))

C.2 0.7 pt

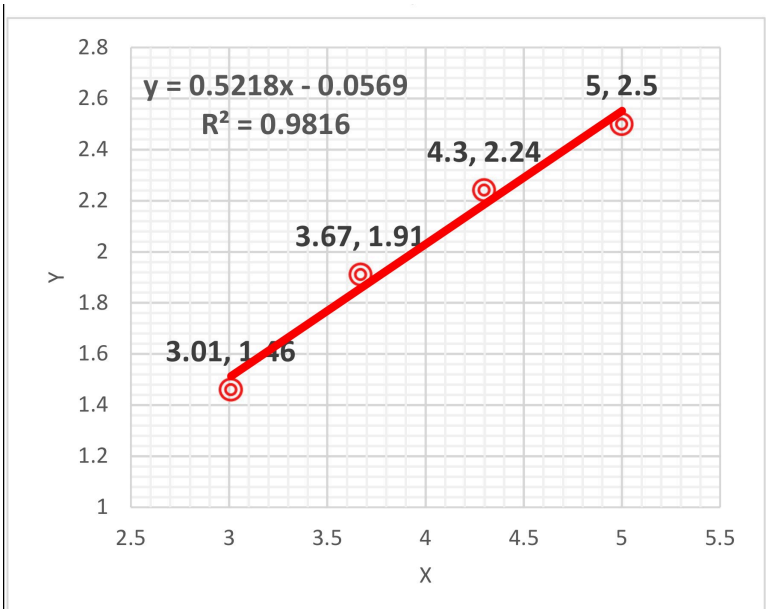
λ (nm)	ΔS_ℓ (cm)	ℓ (μm)	ΔS_w (cm)	w (μm)
488	0.748	58.7	0.860	51.1
	0.750	58.5	0.842	52.1
514	0.787	58.8	0.920	50.3
	0.794	58.3	0.891	51.9
632.8	0.978	58.2	1.12	51.1
	0.960	59.3	1.11	51.4
694.3	1.07	58.2	1.23	50.9
	1.07	58.2	1.22	51.4

$\ell = 58.59\ \mu\text{m}$

$w = 50.78\ \mu\text{m}$

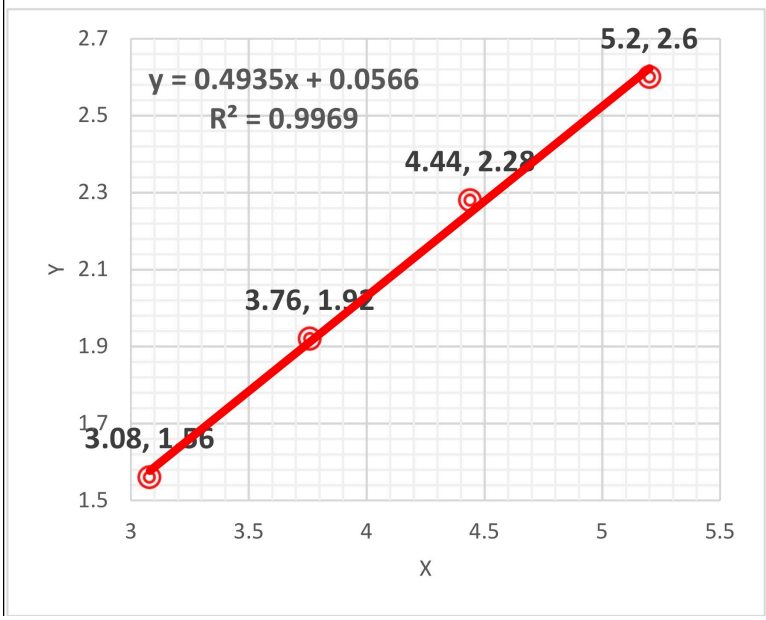
C.3 $\phi = 27°$ 1.0 pt

λ = **488 nm** 축 1 (긴 변) ϕ = **27.6°**



λ = **514 nm** 축 1 (긴 변) ϕ = **26.2°**

λ = **514 nm** Axis 1 (long) ϕ = **26.2°**



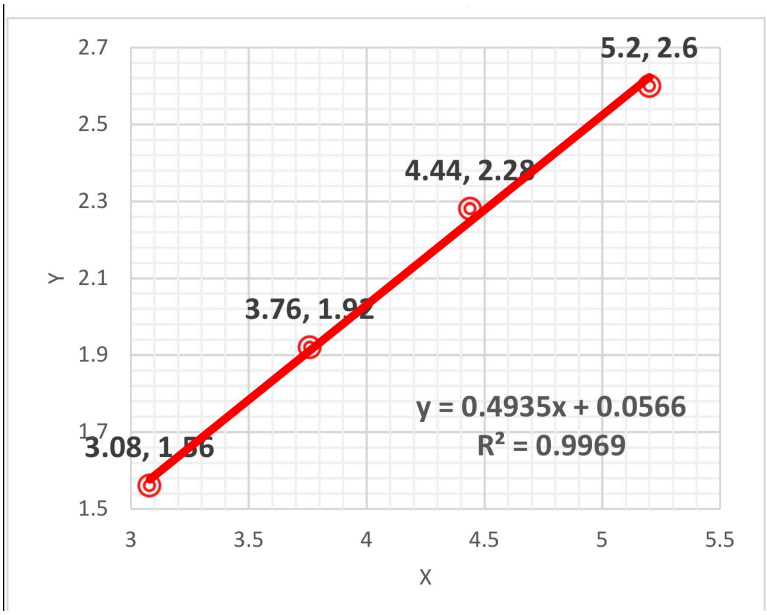
Experiment

Solution

A2

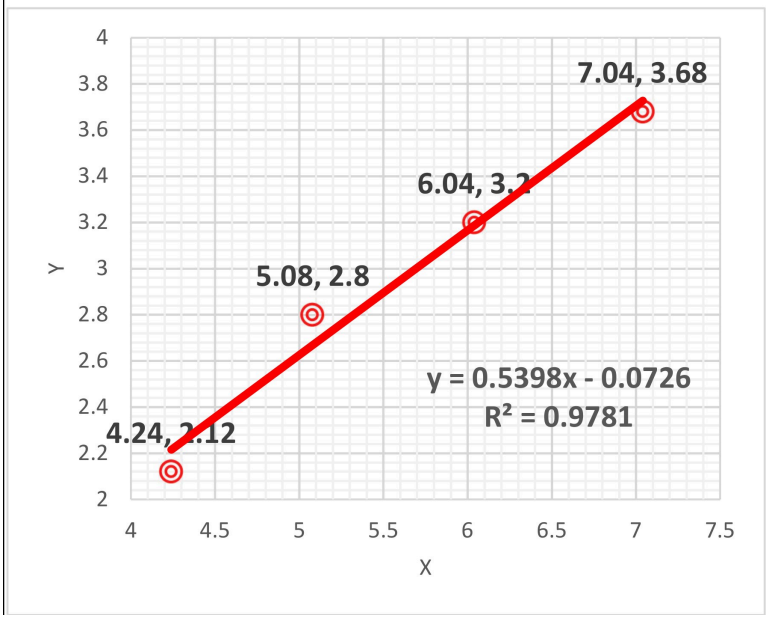
Korean (Korea (Republic of))

λ = **632.8 nm** 축 1 (긴 변) ϕ = **27.7**



λ = **694.3 nm** 축 1 (긴 변) ϕ = **28.4**

λ = **694.3 nm** Axis 1 (long) ϕ = **28.4**



파트 D. 시료 구조 크기의 탐구

D.1 1.9 pt

레이저 파장 λ = **914 nm**

미세 회절 밝은 점의 중심 좌표 (*x*, *y*) 긴 변			
(1.98, 0.40)	**(2.36, 1.62)**	**(2.64, 1.68)**	**(3.02, 1.68)**
(1.96, 0.82)	**(2.32, 1.22)**	**(2.70, 1.28)**	**(3.02, 1.30)**
(1.98, 1.24)	**(2.32, 0.84)**	**(2.66, 0.84)**	**(3.04, 1.66)**
(1.98, 1.66)	**(2.36, 0.42)**	**(2.62, 0.40)**	**(2.98, 0.50)**
미세 회절 밝은 점의 중심 좌표 (*x*, *y*) 짧은 변			
(-2.06, 3.48)	**(-1.72, 3.48)**	**(-1.38, 3.46)**	**(-1.06, 3.46)**
(-2.08, 3.08)	**(-1.74, 3.08)**	**(-1.40, 3.14)**	**(-1.00, 3.12)**
(-2.08, 2.64)	**(-1.74, 2.65)**	**(-1.38, 2.62)**	**(-1.02, 2.62)**
(-2.06, 2.16)	**(-1.68, 2.22)**	**(-1.36, 2.22)**	**(-1.02, 2.14)**

이웃한 점 사이의 거리 ΔS_x, ΔS_y 를 계산하시오

	ΔS_x (cm)	ΔS_y (cm)
긴 변	**0.346**	**0.410**
짧은 변	**0.348**	**0.428**

Experiment

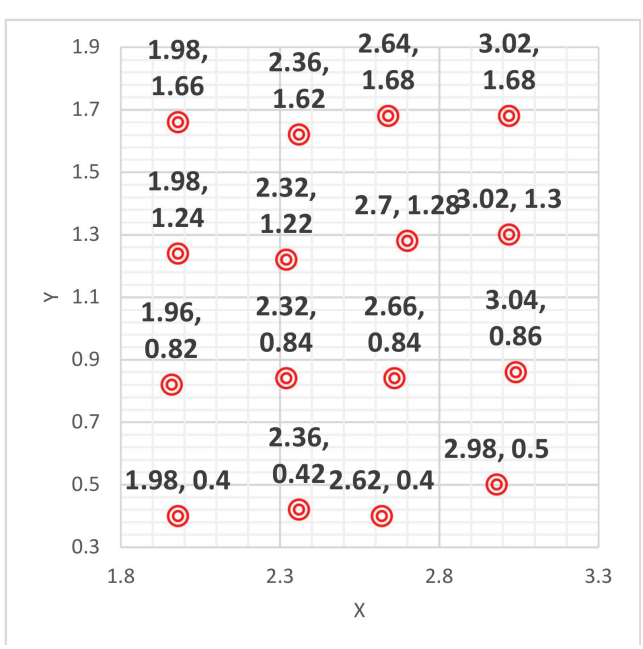
Solution

A2

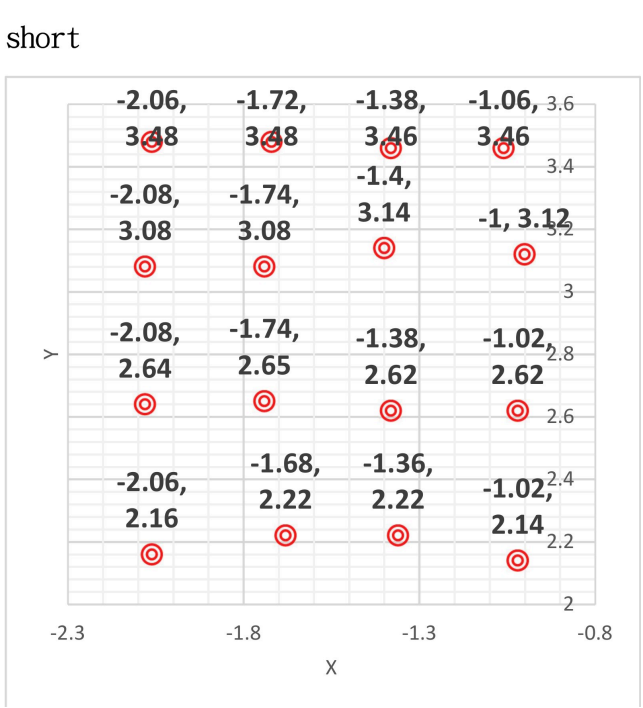
Korean (Korea (Republic of))

D.1.

긴 변



짧은 변



Experiment

Solution

A2

Korean (Korea (Republic of))

Asian Physics Olympiad

레이저 파장 λ = **1152 nm**

미세 회절 밝은 점의 중심 좌표 (*x*, *y*) 긴 변			
(2.16, 0.56)	**(2.60, 0.56)**	**(3.04, 0.56)**	**(3.48, 0.56)**
(2.12, 1.16)	**(2.58, 1.16)**	**(3.06, 1.14)**	**(3.48, 1.12)**
(2.12, 1.64)	**(2.60, 1.66)**	**(3.04, 1.68)**	**(3.48, 1.66)**
(2.14, 2.26)	**(2.62, 2.22)**	**(3.08, 2.18)**	**(3.48, 2.24)**
미세 회절 밝은 점의 중심 좌표 (*x*, *y*) 짧은 변			
(-3.44, 4.44)	**(-2.68, 4.42)**	**(-2.20, 4.42)**	**(-1.78, 4.42)**
(-3.10, 3.86)	**(-2.70, 3.88)**	**(-2.24, 3.84)**	**(-1.82, 3.88)**
(-3.20, 3.38)	**(-2.74, 3.38)**	**(-2.22, 3.34)**	**(-1.76, 3.34)**
(-3.14, 2.78)	**(-2.68, 2.78)**	**(-2.22, 2.78)**	**(-1.76, 2.76)**

	ΔS_x (cm)	ΔS_y (cm)
긴 변	**0.448**	**0.555**
짧은 변	**0.452**	**0.550**

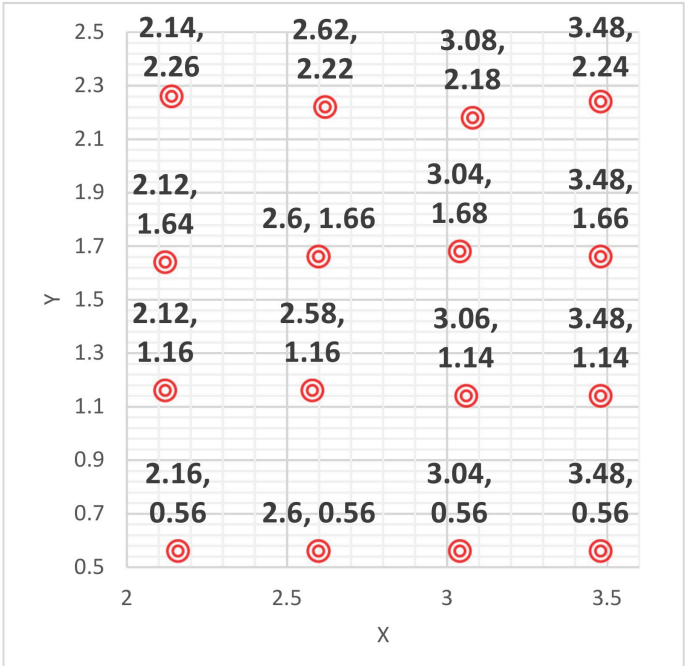
Experiment

Solution

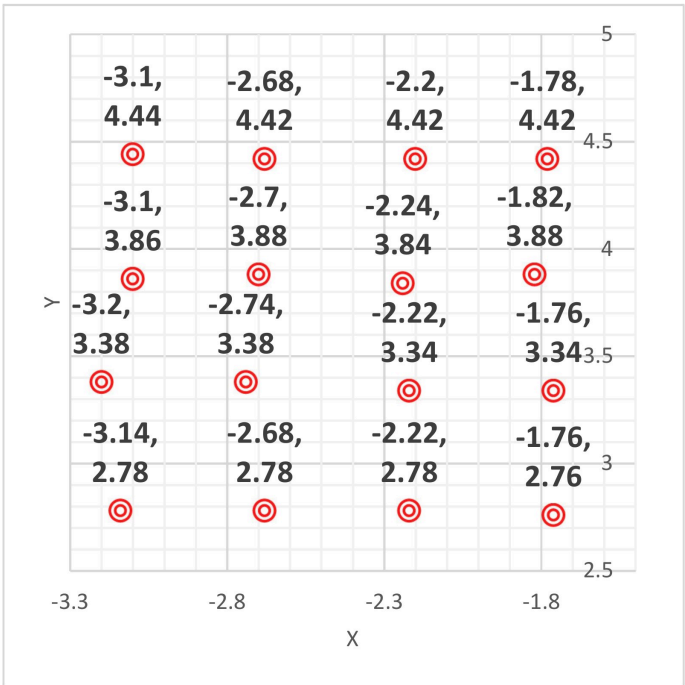
A2

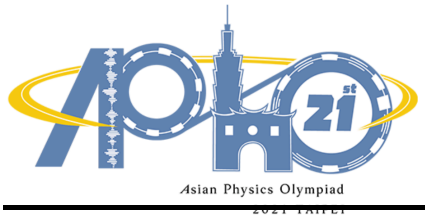
Korean (Korea (Republic of))

긴 변



짧은 변





레이저 파장 λ = **1444 nm**

미세 회절 밝은 점의 중심 좌표 (*x*, *y*) 긴 변			
(3.34, 0.02)	**(3.86, 0.02)**	**(4.42, 0.02)**	**(4.94, 0.04)**
(3.34, 0.70)	**(3.84, 0.72)**	**(4.42, 0.70)**	**(4.94, 0.74)**
(3.36, 1.42)	**(3.86, 1.42)**	**(4.44, 1.40)**	**(5.00, 1.46)**
(3.34, 2.08)	**(3.86, 2.08)**	**(4.48, 2.08)**	**(5.00, 2.10)**
미세 회절 밝은 점의 중심 좌표 (*x*, *y*) 짧은 변			
(-3.86, 4.16)	**(-3.32, 4.18)**	**(-2.74, 4.18)**	**(-2.14, 4.16)**
(-3.84, 3.48)	**(-3.28, 3.48)**	**(-2.72, 3.48)**	**(-2.12, 3.48)**
(-3.80, 2.78)	**(-3.26, 2.78)**	**(-2.72, 2.78)**	**(-2.12, 2.80)**
(-3.78, 2.02)	**(-3.26, 2.06)**	**(-2.70, 2.06)**	**(-2.00, 1.98)**

이웃한 점 사이의 거리 ΔS_x, ΔS_y 계산 0.5 pt

	ΔS_x (cm)	ΔS_y (cm)
긴 변	**0.542**	**0.687**
짧은 변	**0.575**	**0.713**

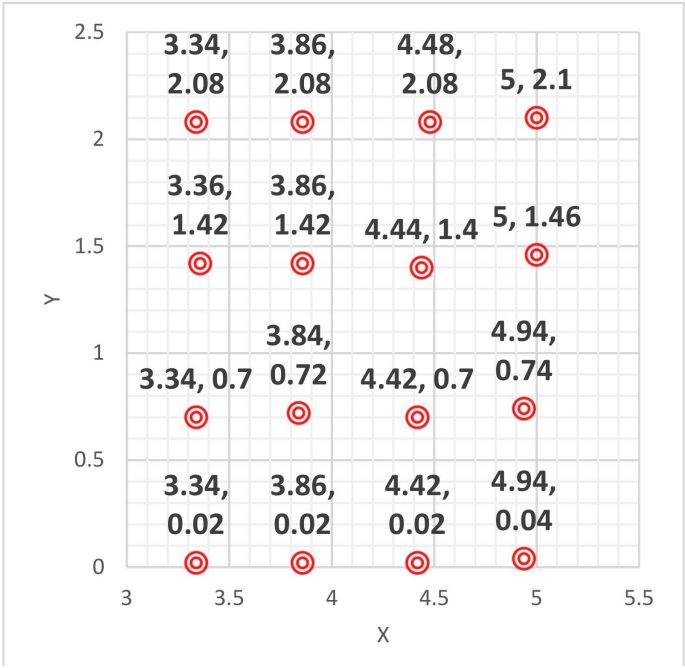
Experiment

Solution

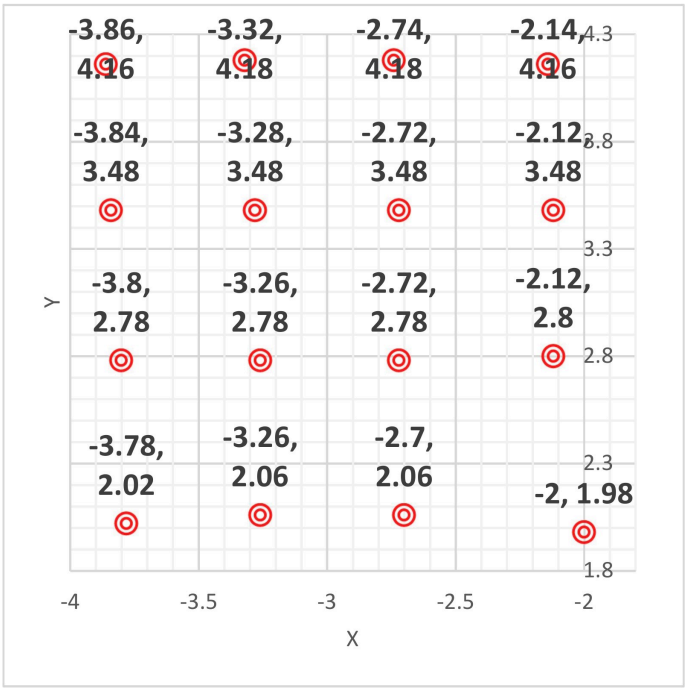
A2

Korean (Korea (Republic of))

긴 변



짧은 변



Experiment

Solution

A2

Korean (Korea (Republic of))

Asian Physics Olympiad
2021 TAIPEI

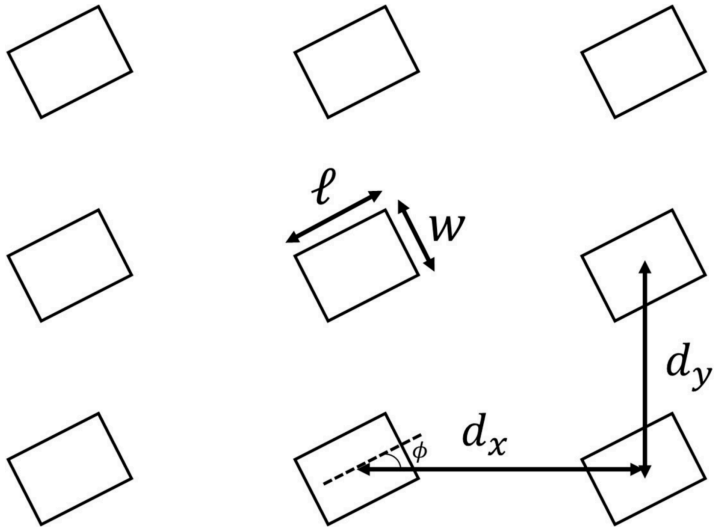
D.2 0.6 pt

$d_x = 249.3\ \mu\text{m} \quad d_y = 198.2\ \mu\text{m}$

λ (nm)	축	d_x (μm)	d_y (μm)
914	긴 축	**251**	**211**
	짧은 축	**250**	**203**
1152	긴 축	**244**	**197**
	짧은 축	**242**	**199**
1444	긴 축	**253**	**199**
	짧은 축	**239**	**192**

파트 E. 시료 구조 크기의 탐구

E.1. 1.0 pt



$(a, \ell, w, d_x, d_y, \phi) =$

(5.627 um, 58.59 um, 50.78 um, 249.3 um, 198.2 um, 27 degree)